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Final Report

AASERT-97
Computational models of individual differences in working memory capacity
Grant F49620-97-1-0455

Objectives

This project involved several inter-related goals. The first was to study how working memory affects performance of cognitive tasks. We then demonstrated that a formally specified, computer implemented model can account for performance at a fine level of detail including performance differences among individuals. Finally, we intended demonstrated that differences in working memory capacity are stable and predictive of performance across several qualitatively different tasks.

Frank Lee and Glenn Gunzelmann both did research on the spatial information processing requirements of complex systems. Frank did work on how people learn to attend to appropriate regions of these visual displays. Working with an air-traffic control simulation, he showed that people came to focus their attention on those regions that were most informative. Glenn Gunzelmann looked at how people relate camera information to map information in the unmanned flight simulation. He showed that participants developed one of two strategies for relating the two sources of information. Both Frank and Glenn developed successful ACT-R models of their respective tasks which were used to direct subsequent research. Michaela Spehn conducted research concerned with how prior knowledge, specifically familiarity with a concept and number

of prior associations affects learning of new information. She was also involved in modeling her behavioral data.

Status of Effort

This is a final report.

Accomplishments/New Findings

We have explored the possibility of predicting the performance of individuals across a range of tasks using a measure of working memory derived from ACT-R modeling. In this model, working memory capacity is represented by source activation, a type of attentional activation used to make information relevant to the current task more available than other information in memory. Our assumption is that source activation varies from individual to individual, resulting in the observed differences in individuals' performance of working memory tasks.

We first showed that we could predict the performance of individual subjects at a detailed level on two variations of a modified digit span (MODS) task. In this task, subjects read sequences of letters and digits and were required to retain the digits for later recall. Working memory load was manipulated by varying the number of digits to be stored before recall. Performance decreased as the number of digits to be recalled increased and this decrease was different for different individuals. As expected, our model captured these individual differences by varying only the source activation parameter. Further, the model successfully predicted recall of digits as a function of their location within the to-be-recall set (i.e., the serial position function).

Then, using estimates of each individual's capacity estimated from the MODS task, we demonstrated our model's ability to predict that person's performance on a second, qualitatively different task. (the n-back task). In this task, subjects are presented with a long sequence of stimuli and are required to indicate whether the current stimulus matches some previous stimulus in the sequence. For instance, in a 2-back procedure, the subject is told to respond positively when the current stimulus matches the second stimulus before the current one. We found that our model successfully captured the performance of individual subjects in this task, using the measure of source activation estimated from the MODS task for each individual. This is the first demonstration of the ability to predict performance on one task from performance on a different task at the level of the individual subject.

Personnel Support

AASERT

1. Frank Lee
2. Glenn Gunzelmann
3. Michaela Spehn

Grant: Computational models of individual differences in working memory capacity

1. Lynne M. Reder, Principle Investigator
2. Marsha C. Lovett, Research Scientist
3. Larry Z. Daily, Postdoctoral Researcher

Publications and Manuscripts

Lovett, M.C., Daily, L.Z., Reder, L. M. (2000). A Source Activation Theory of Working Memory: Cross-task Prediction of Performance in ACT-R. *Journal of Cognitive Systems Research,* 99-118. Also available at:
http://www.elsevier.nl/inca/publications/store/6/2/0/2/8/8/?menu=cont&label=table

Daily, L.Z., Lovett, M.C., & Reder, L. M. (2001). Modeling Individual Differences in Working Memory Performance: A Source Activation Account. *Cognitive Science, 25,* 315-353 [lead article].

Daily, L. Z., Lovett, M. C., & Reder, L. M. (in press). Modeling individual differences in working memory performance: A source activation account. Cognitive Science.

Lovett, M. C., Daily, L. Z., & Reder, L. M. (in press). A source activation theory of working memory: Cross-task predictions of performance in ACT-R. To appear in Cognitive Systems Research.

Lovett, M. C., Reder, L. M. & Lebiere, C. (1999). Modeling working memory in a unified architecture: An ACT-R perspective. In Miyake, A. & Shah, P. (Eds.), Models of Working Memory: Mechanisms of Active Maintenance and Executive Control. New York: Cambridge University Press.

Interactions/Transitions

Marsha Lovett gave a presentation at the Models of Working Memory Symposium on our initial attempts to model MODS data. Larry Daily presented the results of later efforts, including the cross-task predictions, at the Fifth and Sixth Annual ACT-R Workshops. The full references are listed below.

Daily, L. Z., Lovett, M. C. & Reder, L. M. (1999). Cross-task prediction of working memory performance: Working memory capacity as source activation. Paper presented at the Sixth Annual ACT-R Workshop, Fairfax, VA.

Daily, L. Z., Lovett, M. C. & Reder, L. M. (1998). Modeling individual differences in working memory capacity. Paper presented at the Fifth Annual ACT-R Workshop, Pittsburgh, PA.

Lovett, M. C., Reder, L. M., & Lebiere, C. (1997). Modeling Working Memory in a Unified Architecture: The ACT-R Perspective. Paper presented at the Models of Working Memory Symposium, Boulder, CO.